SPEC Kit 348

Rapid Fabrication/Makerspace Services

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EXECUTIVE SUMMARY

Introduction

Rapid fabrication technologies, or "3-D Printing," to use the less accurate but more familiar term, have undergone rapid evolution and are now used for medical implants, prosthetics, teaching aids, information visualization, research on rare/fragile objects, architecture, art, and advanced manufacturing. These technologies are rapidly lowering a number of different barriers faced by researchers and others, barriers that had previously made it prohibitively difficult for most individuals, researchers, and organizations to manufacture objects without significant investment of time and money in training and equipment. Because of these advances, the complexity and range of objects that may now be manufactured has increased precipitously, including easily customized items or precisely replicated physical objects, while the process by which these may be manufactured has flattened, allowing on-site or local manufacture and reducing lead time (in some cases permitting even just-in-time manufacturing processes).

These technologies produce intellectual assets—sensor and digitization data, as well as models and methods—that are potentially valuable to other researchers for future reuse and replication. Moreover, these technologies offer the opportunity to create spaces ("makerspaces") that facilitate research, collaboration, information discovery and management, and a form of technical and information literacy.

Strategic Relevance to Libraries

In the last several years, the interest of libraries in this space has been growing rapidly. Fabrication technologies and makerspaces are strategically relevant to research libraries for at least three reasons.

First, makerspaces represent a unique use of library space. The assessment and renovation of libraries' use of space has been recognized as a current strategic issue for libraries in general. As Joan Lippincott notes in *Research Library Issues*[1], it is essential that library space assessment be informed by campus priorities related to teaching and learning, expanding beyond library-centric thinking to design proactive spaces that engage with student learning more broadly. Makerspaces offer a key potential opportunity for such engagement, while creating spaces that align with the library mission, synergize with other services, and integrate staff competencies like information management.

Second, libraries are increasingly engaging with data management. Digitization and fabrication technologies both make use of and produce research data—data describing objects, models, and the sensor information collected from them. Makerspaces offer a clearly scoped locus for the integration of data management with other services and resources.

Third, we are now seeing fabrication figure increasingly throughout the various stages of the research lifecycle, and there is a clear trend towards adoption in higher education generally.[2] These technologies may be used early on as part of prototyping for research interventions or to embed sensors for research data collection, or later on as part of analysis or research collaboration (e.g., by materializing models for examination and sharing).

Further, libraries have a number of core competencies that are complementary to fabrication:

- Fabrication extends the information lifecycle. Fabrication technologies make information material and, conversely, help make material objects into information.

- Libraries support the research process. Use of fabrication technologies requires a core set of skills and knowledge (such as databases of models) outside of specific research domains and requires skills and knowledge that are not in the sole domain of any one discipline.
- Libraries promote literacy broadly. Use of fabrication technologies promotes design, science, technology, engineering, art, and mathematics.
- Libraries are responsible for maintaining the scholarly record. The data, digitizations, designs, and models produced as part of rapid fabrication approaches can constitute unique and valuable parts of the scholarly record.
- Libraries provide commonly accessible physical spaces designed for research and learning. Successful makerspaces bring together accessible locations, thoughtfully designed space, curated hardware and software, skilled staff, local information management, and global "reference" knowledge.

Survey Highlights

The goal of this survey was to gather information for senior library staff to support decisions related to engagement with 3-D printing, rapid fabrication and digitization technologies, and makerspaces, in general, and in particular to inform decisions regarding the types of service offerings libraries can provide, resources needed, and evaluation of the service. These results are based on 64 responses from the 124 ARL member libraries (52%) by the deadline of June 12, 2015.

Service Offerings

Makerspaces appear to be of significant interest to ARL libraries. A substantial majority of the responding libraries (41, or 64%) are currently engaged with makerspace service deployment (providing, piloting, or planning the service). Another 11 (17%) plan to investigate these services in the future. Only 12 respondents have no plans to enter this domain (Q1). The respondents that are currently engaged with makerspace service deployment were asked to complete the survey. The others were directed to a question on futurecasting.

Of those libraries engaged in makerspaces, the majority offer, or plan to offer, a combination of core services including reference, training, hardware, scanning, and model repository, while a substantial minority are also engaged in collection development around 3-D models (Q5). In addition to these core services, almost all of these libraries offer, or plan to offer, use of 3-D printers. More than four-fifths support 3-D design and conversion software, and more than three-quarters provide 3-D scanners (Q13, Q15).

While only a minority of these libraries offer additional hardware and services beyond 3-D printers and scanners, the breadth of technologies being explored is impressive (Q5, Q13, Q15). The responding libraries support a wide range of CAD, visualization, animation, drawing, and audio production software, as well as software specific to scanning and printing systems. They provide an even wider range of hardware, including hand tools (carpentry tools, sewing tools, soldering irons, and 3-D pens); electronics (microcontrollers, electronic kits, motors, wearable/soft circuits, and sensors); visualization equipment (digital globes, virtual reality goggles, digital surfaces, and visualization walls); subtractive fabrication (laser cutters and CNCs); large mechanical tools (drill presses, and industrial sewing machines); large format printers and scanners; and drones.

These hardware and software offerings are supported with online resources, reference services, and training sessions. Almost all of the responding libraries offer, or plan to offer, in-person technology training and skill-building sessions. Approximately three-quarters use LibGuides or other resources, supply documentation, or provide reference services (focusing on design, models, and software) to support hardware and software use (Q17, Q18, Q19, Q22).

Implementation and Resources

Libraries investigate makerspaces for a variety of reasons, most commonly because library staff or administration recommended developing these services, or because they were identified as a priority during strategic, space, or renovation planning (Q2). While direct user requests and user need evaluations were a less common motivator (cited by approximately a third of respondents), almost all libraries expect substantial service use from undergraduates, with four-fifths and half of libraries expecting substantial use from graduate students and faculty respectively (Q2, Q3, Q26).

The responding libraries are funding makerspaces using existing resources. Almost four-fifths fund their makerspaces from their general budget, and 85% use only existing staff to support these services. Fewer than a third of libraries currently charge any kind of fee for the service (Q14, Q30, Q33, Q35).

Offering makerspace services typically requires allocating staff time, purchasing hardware and software, and preparing space. Staffing was most commonly (modally) named as the largest single expense, although substantial clusters of respondents named equipment or materials (respectively) as the largest expense (Q32, Q36).

The median library makerspace service involves three staff members, contributing portions of their time (Q32). Staff are drawn from across the library. Those roles contributing at least 20% FTE to library makerspaces and services include: lab assistant, student technician, lab manager, design architect, digital fabrication specialist, digital media mentor, developer, graduate research assistant, multimedia specialist, arts librarian, science librarian, and even head of circulation (Q33). (The significant staff requirements may explain why most libraries offer limited hours for makerspace services—see Q29.)

Planning also requires a significant investment of staff time. Of those libraries that fielded a service, most reported spending several months or more developing the service, while some libraries reported spending up to a year (Q4, Q6).

Although most respondents did not identify the construction, renovation, or preparation of space as a dominant expense, there were large variations in the reported space required. While the average amount of space used is approximately 310 square feet, the upper range reported was 9000 square feet (Q11).

Evaluation

Libraries' formal evaluations of their engagement with makerspaces were quite positive. Forty percent of the libraries (15 of 38) have conducted some formal assessment, most by collecting usage data, observing of users, and user satisfaction surveys (Q40, Q41). As a result of these assessments, approximately half of the libraries identified the need for altered or expanded services, and none identified the need to eliminate or reduce services (Q43).

Frequently reported challenges clustered around the dual themes of resources and maintenance. Funding and staff time are a recurring challenge, especially because the hardware requires training, adjustment, and maintenance (Q50, Q52). These challenges are manageable—no horror stories were reported, and many respondents encouraged experimentation, patron outreach, and keeping an entrepreneurial perspective. This was articulated well in a number of respondent comments, which note that hardware is not a "turnkey" solution and requires a "DIY [do-it-yourself] ethos" (Q54).

Overall, respondent comments about the role of the makerspace in their libraries are overwhelmingly positive (Q53). They said that makerspaces are "a catalyst for innovation," "a component of scholarly communication," "hubs for participatory and collaborative learning," the "next steps for active learning and presentation of scholarship,"and that they "foster creativity." One respondent crisply articulated a general theme touched on in many of the comments: "A central department-free place on campus for this technology is key, since the applications are so broad… Having a library service solves this problem and opens up the technology to the entire community." There was, however, a note of caution sounded, as well—a number of respondents emphasized that the core competitive advantage of the library is not in providing hardware or simple physical space but in creating an environment that combines service, space, and expertise to foster individual and collaborative "investigation, interrogation, and learn[ing] through doing."

A Rapidly Changing and Challenging Area

As the survey results reveal, many research libraries are engaging with making and makerspaces. This area remains both exciting and challenging. These technologies are rapidly evolving, which presents a challenge to the libraries that need to buy and maintain them. For example, within roughly the last eighteen months, there have been a raft of 3-D printers and scanners introduced into the market at all price points from hobby-level, through consumer, business, and manufacturing grade. Although consumer-level 3-D printers require relatively little capital investment, more advanced rapid fabrication technology can be expensive, requiring extensive setup and maintenance, as well as dedicated space. Some hardware even requires specialized plumbing, HVAC, or access control.

This technology shift has some advantages. Prices are dropping, and technologies in development have the potential to dramatically improve the capabilities of consumer- and professional-grade equipment—in the speed of printing, ease of use, cost of maintenance, and range of materials. Some of the benefits of these advances may be huge. For example, the ability to use multi-material printing technologies could allow the integration of working electrical circuits in printed objects, which greatly expands the potential types of objects that can be designed, as well as the potential range of applications.

The expertise and skills needed to support makerspaces and services is also complex. Library patrons will need support to determine whether rapid fabrication will be of use to them, discover existing models and design solutions (using specialized databases and collections), alter models or scan or design new ones (using specialized software), select service bureaus, and use locally hosted fabrication tools. They will also need support in managing the data (models) they produce, and in sharing or archiving them. Expertise is also needed to set up and maintain the makerspace tools and infrastructure.

Some of this support involves discovery, data management, and reference interview expertise that is within the traditional training of librarians. However, making also draws on skills and expertise from multiple disciplines, including design, engineering, electronics, and architecture. Moreover, some experience with tool use is highly device-specific and requires tactile feedback; as such, it can be gained only by using the appropriate physical tools. Further complicating matters is the fact that there is little formal guidance available for libraries that wish to engage in the development of a makerspace or services, and there are few established sets of best practices, training, or reference publications that may be used to guide selection and development of these practices.

Finally, the rapid change in technology also impacts both the cost and attractiveness of makerspace service offerings. In the last eighteen months, major retailers, such as Staples, UPS, and Office Depot, have entered into the market both as retailers and as print-on-demand service providers, while former niche leader Makerbot has experienced a substantial contraction. This is likely to have the effect of creating new opportunities for reference and design support, while reducing the attractiveness of services that offer only low-end, consumer-grade printing—that is, those that are already increasingly available to the public.

In sum, while libraries can field small pilot services or experiments in 3-D printing with relatively few resources, support for advanced making can require substantial investment—and investments in hardware involves heightened risk because of the rapid changes in technology. Because of this technological instability, libraries creating makerspaces and services should thoughtfully consider how investments can be made in staff, focusing more, perhaps, on developing expertise and service rather than on providing extensive hardware and facilities.

Discussion

Library Interest is Steady and Substantial

This is the first comprehensive survey of ARL member libraries in this area, so trends are challenging to gauge. Only two other recent surveys have been conducted,[3] and these have substantial limitations in design and coverage. A convenience sample survey of libraries in all classes was conducted in 2013, which found that 41% of libraries sampled had some form of fabrication or maker service while another 36% were planning such services.[4] The results from this SPEC survey indicate that 27% of the responding libraries (17 of 64) are engaged with services in this area and 37% are in the investigation and planning stages. While this is insufficient to establish a statistical trend, it suggests that interest in rapid fabrication/makerspace services is steady and substantial.

Formal Guidance is Limited

The libraries that responded to this survey have constructed guides and tutorials for clients and have identified online books, articles, video tutorials, software, and collections of models that are useful to a broader audience. Nevertheless, existing resources in this area remain sparse. Survey respondents and our own literature reviews revealed that relatively little information is available online or in print that can be used to guide patrons in determining whether rapid fabrication will be useful to them, to help them discover and alter existing models, or to teach them to scan or design new ones, or to support the fabrication of an object from these models. Nor are there established best practices or off-the-shelf solutions for libraries in this area.

We were able to identify some useful online resources, which are listed in the bibliography. However, we would recommend that libraries engaging in this area also participate in maker events—such as conferences and "faires"—to learn directly about emerging uses, trends, and to gain hands-on experience.

Respondents, while reporting generally positive experiences with these services, cautioned that manufacturer service and support is often uneven and that even recent mass-market products require tinkering and maintenance. Running a makerspace requires a willingness to do-it-yourself.

The Audience is Broad

It is, perhaps, unsurprising that we've encountered a wide variety of applications in our interviews with students, staff, and faculty at MIT over the past year. Some use rapid fabrication technologies in medical engineering, while others employ the technologies for such diverse projects as prototyping robotics, supporting collaborative design of a satellite, visualizing information, and even developing new fashions. Meanwhile, other MIT researchers have developed new methods for printing everything from houses, to solar cells, to artificial bones and skin. The ARL survey results, however, make clear that the broad appeal of these technologies extends beyond technology-focused universities, such as MIT. As one respondent put it, "During our pilot phase, we gauged interest from anyone we could talk to, and it became clear that the applications for this technology are so broad that any department could use it."

Outlook

While no trend data is yet available regarding ARL member libraries' engagement with 3-D printing and similar technologies, it is evident from the survey data that considerable effort is going toward mapping and forecasting community needs and developing appropriate library services and resources. Unsurprisingly, resource allocation is a primary concern, given that most respondents report funding makerspaces and attendant costs from existing operating budgets. The rapid advancement of technologies, as well as the increase in readily accessible consumer-level printing services, complicate libraries' ability to invest in and maintain equipment that will serve their communities into the mid-term—on the flip side, however, the novelty of the technology and the rapid expansion of possible applications are characteristics that generate enthusiasm and make the makerspace an opportunity for vibrant community outreach and collaboration.

The center of balance between these potential risks and rewards will vary depending on institutional context—in some cases, individual schools, departments, or labs may provide access to rapid fabrication equipment, and so, in addition to consulting peer institutions regarding the latter's makerspace experiences, it is critical to map existing institutional services (including who can access them) and identify gaps which may be productively addressed by the libraries, whether independently or collaboratively. In order to develop a sustainable model, the rapidity with which technology is changing should be factored into service models realistically, as should the costs of equipment maintenance, staff time related to makerspace supervision, and staff time related to instruction and outreach. Models should also include regular assessments in order to identify areas for improvement and expansion and to ensure responsiveness to user needs in a shifting environment. Finally, the purpose of the makerspace service should be clearly articulated and closely tied to the library's and institution's respective missions to ensure continued relevance.

Certainly, responding institutions appear to recognize that the nature of the technology dovetails with the function of academic research libraries, offering a novel means of engaging students, faculty, and affiliated researchers that intersects with both emerging library roles like data management and traditional functions related to information access and preservation—and, as researchers increasingly incorporate the technology throughout the research lifecycle across disciplines, it will become more and more necessary for libraries to provide expertise and other forms of support in this area.

Endnotes

1 Joan Lippincott and Kim Duckett, "Library Space Assessment: Focusing on Learning," *Research Library Issues*, no. 284 (2013): 12–21, http://publications.arl.org/rli284/12

2 Larry Johnson, et al., "The NMC Horizon Report: 2013 Higher Education Edition." (2014): 1–40, http://www.nmc.org/publication/nmc-horizon-report-2013-higher-education-edition/

3 Gary Price, "Results From 'Makerspaces in Libraries' Study Released," *Library Journal* (Infodocket). (December 16, 2013) http://www.infodocket.com/2013/12/16/results-of-makerspaces-in-libraries-study-released/; PRG, "Survey of 3D Printing in the Library," Primary Research Group (2014)

4 Gary Price, "Results From 'Makerspaces in Libraries' Study Released," *Library Journal* (Infodocket). (December 16, 2013) http://www.infodocket.com/2013/12/16/results-of-makerspaces-in-libraries-study-released/